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Carnation Crop Control

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CARNATION CROP CONTROL

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INTRODUCTION

The period of highest market demand for the carnation is usually from late fall to late spring. At the beginning of these studies the means for providing a continuous supply of flowers for the period of greatest demand were not well known. Carnation stems were usually pinched until the middle of July and flower production started in early fall. This was followed by a drop in production in late winter or early spring, but by June the production was far greater than demand.

It was the purpose of these studies to investigate the growth and flowering of the carnation with special emphasis placed on timing for flowering at specific periods.

REVIEW OF LITERATURE

Considerable work on carnation crop control has been done at Colorado A & M College. In the earliest work, Holley (1) found that plants of the variety William Sim were in peak crop about 6 months after pinching. He also reported that the return crop from an October 17 first crop was in peak production in about 6 months. This return crop was almost completely cut off the plants in a period of 3½ months. On the basis of this work he believed that there would be a period of 6 to 7 months between the first crop in the fall and the return crop in the spring. However, in later work with plants of Crowley's Pink Sim, Holley and Caparas (9) found that it was only about 5 months between the first crop in October and the return crop in the spring. They reported that when the fall crop was cut high on the plants, the quality of the stock was inferior because of the reduction in stem length, but this high cut did increase spring production; however, there was no appreciable reduction of time between the two crops. The data of Wagner and Holley (11) show that the time interval between pinching and peak production of the crop was 4 months for stems pinched either August 1 or 15. Each crop was cut completely in a period of 4 to 4½ months. One of their conclusions in this work was that the terminal shoot produced a flower more rapidly if there were several sub-terminal shoots.

Holley and Wagner (8), using plants of the variety William Sim and several of its sports in single pinch culture, found that if the first crop was cut high, the second crop was larger and it was produced over a longer period of time. They also reported in this work that the warmer the weather at the time of the first crop, the shorter the time from cutting the first flower to the last.

In respect to methods of pinching, Holley (4) reported that the manner of making the second pinch was not important. He found that distribution of the crop was affected slightly, but that quality and quantity were not affected appreciably. This work was done with plants of White Sim.

As a result of pinching White Patrician plants on August 15, which was later than usual, Holley (2) found that production was increased in the period November through March. This led to his recommendations to pinch high on the shoot in August to give better distribution of production regardless of a possible reduction in total production. In a later study (6) with plants of Red Sim, Holley projected the anticipated production from plants given the first pinch July 2 and additional pinches in a 2-week period following August 8. He believed that production would be uniformly high from October through June. The experiment was terminated early in the season so that there were no data for the later period.

Some of the problems of keeping carnation plants in production for more than one year have been studied by Holley (3) (7). With plants kept in continuous production he compared removal of some plants, removal of some shoots, June and July pinching, and a June 10 cut-back. He concluded that none of the treatments were ideal. The cut-back and thinning operations lowered production, and the June 10 cut-back caused the crop to reach peak production in February. He recommended (3) cutting flowers low in the spring to allow more light to reach inner stems, then followed with a cut-back on May 20 to June 1 for heavy production in December.

Following some later work (7) he recommended gradual pruning where the stems should be cut back to within 3 inches of the dead foliage. He suggested that this pruning be done in four steps at 2-week intervals, or in three steps at 3-week intervals. The gradual pruning could be done whenever desired. According to his schedule, William Sim plants pruned in late March return to production in September. Those pruned in mid-May return to production in early December.

Holley (5) reported on a study made to determine the effect of soil temperature on the time of production. He used soil temperature ranges from 45 to 50° F., 55 to 59° F., 60 to 65° F., and 65 to 70° F. during the spring, and found that there was little or no effect on summer cropping of White Sim plants.

RESULTS OF OHIO STUDIES

MULTIPLE PINCHING

In the past, accepted cultural practices for carnations have provided for propagation by stem cuttings during the winter or spring. As shoot growth progresses on the new plant, the terminal end is removed by pinching so that a multiple-branched plant is produced. It has been a common practice to continue such pinching until about the middle of July.

Origin of Flowering Shoots

The first study in 1948 was designed to analyze the origin of flower production from plants handled in the accepted commercial manner at that time.

Rooted cuttings of plants of the variety William Sim were potted in January, 1948, grown in the greenhouse until early April when they were planted 6 × 6 inches outdoors in beds of steam-sterilized soil. On May 22, the plants were dug and benched 8 × 8 inches in raised benches in the greenhouse. Approximately 750 plants were used in this study. General cultural practices recommended by Laurie and Kiplinger (10) were followed.

Stems were tagged as they were pinched and later the resulting shoots were likewise tagged, indicating the pinch date and position of the shoot on the main stem. When the flowers were cut, the information from the tag was recorded, and a new tag was placed on the remaining portion of the stem which indicated the date the flower was removed. Later, the newly developed shoot was tagged, indicating the date of the cut and the position of the shoot on the stem. This made it possible to determine the time relationship between either pinching or cutting and subsequent flower production.

Examination of the data in Table 1 shows that the type of pinching employed in this study provided quite uniform production from November through May. The increase in production that occurred in June originated from the stems that were cut in early fall. About one-fourth of the total production was the return crop from this fall production. Over 50 percent of the total flower crop arose from stems

TABLE 1.—The distribution of total flower production as affected by time of pinch and time of first crop production, variety William Sim, 1948-1949

Time of production	Flower production expressed as percentage total distribution per month from stems pinched on						Return crop from fall	Total
	May 1	May 15	June 1	June 15	July 1	July 15		
October	0.2	0.1	1.9	1.0	1.5	0.2	——	4.9
December	0.5	1.3	1.2	0.4	4.3	3.2	——	10.9
November	0.5	0.4	2.0	1.3	5.1	1.5	——	10.8
January	0.5	0.9	1.1	0.3	3.7	4.3	——	10.8
February	0.4	1.2	0.7	0.9	3.2	5.6	0.1	12.1
March	0.2	0.9	0.4	0.1	2.8	3.2	1.2	8.8
April	0.4	0.2	0.1	0.7	2.2	3.1	2.8	9.5
May	——	0.2	0.1	0.8	0.6	1.8	4.7	8.2
June	——	0.1	0.1	0.2	2.0	5.1	16.4	23.9
Total	2.2	5.3	7.6	5.7	25.4	28.0	25.2	

Total flower production was 976, and the number of flowers per square foot per year was 23.8.

pinched in July. A large percent of the stems pinched earlier produced shoots soon enough so that these new shoots could be pinched on July 15.

The top shoot on the stem usually developed most rapidly, and the succeeding shoots below it were somewhat slower (Table 2). This created a situation in which the second or third shoot below an early pinch produced a flower at the same time as the top shoot from a later pinch.

Data in Table 3 show that the second or return crop came largely from the stems cut in October and November. There was not enough time for the majority of the shoots developing from stems cut in January or later to develop flowers by the first of July.

The Effect of Method of Pinching on Time of Flower Production

In 1951 a study was started to evaluate the effects of different types of pinches. A total of 1,320 plants of the variety Northland were used in 24 different pinching treatments. The spacing of plants in this test was 8 × 8 inches. On two different lots of plants the first pinch was made April 16 and May 8. Three types of pinch were used: the extraction pinch was made when the plant was very young and with little internodal elongation; the commercial pinch was made when there were five or six visible internodes; and the shoot-in-bud pinch was made

after considerable growth had taken place and a terminal flower bud was visible. At least four or five nodes remained on each stem after pinching. In many instances where the shoot-in-bud pinch was used, lateral branching had already started before pinching. Propagating dates were scheduled so that cuttings of those plants receiving the

TABLE 2.—The distribution of total flower production as affected by time of pinch, position of shoot, and time of production, variety William Sim, 1948-1949

Time of production	Flowet production expressed as percentage total distribution per month from stems pinched on											
	May 1				May 15				June 1			
	Shoot position*				Shoot position*				Shoot position*			
	1	2	3	4	1	2	3	4	1	2	3	4
October	—	0.1	0.1	—	0.1	—	—	—	1.7	0.2	—	—
November	—	0.3	0.2	—	0.2	0.2	—	—	1.0	1.0	—	—
December	—	0.1	0.4	—	0.2	0.7	0.5	—	0.4	0.8	—	—
January	—	0.4	0.1	—	0.2	0.3	0.4	—	0.1	1.0	—	—
February	—	0.2	0.2	—	0.2	0.4	0.6	—	—	0.5	0.2	—
March	—	—	0.2	—	—	0.5	0.4	—	—	0.4	—	—
April	—	0.1	0.2	0.1	—	0.2	—	—	—	0.1	—	—
May	—	—	—	—	—	0.1	—	0.1	—	—	0.1	—
June	—	—	—	—	—	—	—	0.1	—	—	0.1	—

Time of production	Flowet production expressed as percentage total distribution per month from stems pinched on											
	June 15				July 1				July 15			
	Shoot position*				Shoot position*				Shoot position*			
	1	2	3	4	1	2	3	4	1	2	3	4
October	1.0	—	—	—	1.5	—	—	—	0.2	—	—	—
November	1.3	—	—	—	5.1	—	—	—	1.5	—	—	—
December	—	0.4	—	—	4.2	0.1	—	—	3.0	0.2	—	—
Januarry	0.1	0.2	—	—	2.7	1.0	—	—	4.0	0.3	—	—
February	0.4	0.5	—	—	1.0	1.9	0.2	—	4.7	0.9	—	—
March	—	0.1	—	—	0.8	1.9	0.1	—	1.6	1.4	0.2	—
April	0.1	0.6	—	—	0.7	1.2	0.3	—	1.3	1.6	0.2	—
May	—	0.6	0.2	—	0.1	0.5	—	—	0.7	0.8	0.3	—
June	—	0.1	0.1	—	0.3	0.7	0.9	0.1	0.8	2.9	1.1	0.2

* 1 indicates terminal shoot, 2 is first sub-terminal shoot, etc.

Total flower production was 976, and the number of flowers per square foot per year was 23.8.

TABLE 3.—The amount of flower production resulting from first crop removal, variety William Sim, 1948-1949

	Time of first crop						
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Number of first crop flowers	47	105	106	105	118	86	93
Number of second crop flowers	72	96	45	15	90	4	——
Percentage of flowering shoots from the first crop which produced a second crop	153.1*	91.6	42.7	14.0	7.5	5.2	0.0

*More than 1 shoot per stem.

extraction pinch were rooted 5 weeks before the first pinch; those receiving the commercial pinch were rooted 7 weeks before the pinch; and those for the shoot-in-bud pinch were rooted 9 weeks before the pinching date.

The plants from each pinching method were divided into four lots, and the subsequent pinching methods were extraction, commercial, high, and combination of the three. The high pinch was made after considerable elongation of the internodes had taken place and at such a position so that six or seven nodes remained on the pinched stem. With the extraction and commercial methods there were only three or four nodes below the pinch. The combination method provided that various shoots on the plants were pinched by means of one of the three types depending on the stage of their development. The plants were examined weekly, and the shoots were pinched when they had developed to a stage suitable for the type of pinch that was to be used. The last pinch was made on July 17. Practically all of the high and combination pinches were made on the last pinching date. All of the shoots that were pinched on July 17 were tagged so that flower production from those pinched shoots could be traced.

Lateral branching was good with the shoot-in-bud first pinch (Table 4) and poorest with the extraction type pinch, and the shoots were slower to develop after the extraction type pinch as evidenced by the fewer shoots that received another pinch (Table 5). Fewer pinches per plant were made when the high method was employed, and as would be expected, there were fewer shoots at the proper pinching stage from the later first pinch made on May 8.

TABLE 4.—The effect of the type of first pinch on the number of shoots produced per plant of the variety Northland, 1951-1952

Type of pinch	Number of shoots per plant from stems pinched	
	April 16	May 8
Extraction	3.0	3.3
Commercial	3.2	3.8
Shoot-in-bud	3.8	3.8

There were no consistent differences in yearly total flower production from the plants given the various pinching treatments (Tables 6 and 7). However, the distribution of the flower production varied somewhat with the type of the last pinch. Flower production was earlier from plants where shoots received the high pinch (Tables 8 and 9). In general, flower production was delayed with plants that received the combination pinch. The type of first pinch apparently had no observable effect on flower production.

TABLE 5.—The number of stems per plant that were pinched following the first pinch, variety Northland, 1951-1952

Types of pinch		Number of stems from the	
First	Succeeding	April 16 pinch	May 8 pinch
Extraction	Extraction	2.9	1.6
Extraction	Commercial	2.2	1.7
Extraction	High	1.1	0.2
Extraction	Combination	2.6	1.8
Commercial	Extraction	3.2	2.9
Commercial	Commercial	3.0	2.6
Commercial	High	1.2	0.8
Commercial	Combination	2.7	3.0
Shoot-in-bud	Extraction	3.3	2.8
Shoot-in-bud	Commercial	2.7	2.3
Shoot-in-bud	High	1.3	0.9
Shoot-in-bud	Combination	3.2	2.6

TABLE 6.—The yearly flower production as affected by various types of pinches. First pinch made April 16, variety Northland, 1951-1952

Type of pinch		Total no. of flowers	Ave. no. of flowers per sq. ft.	Flower production expressed as percentage distribution by month								
First	Succeeding			Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Extraction	Extraction	282	20	1	14	12	11	12	9	6	9	24
Extraction	Commercial	234	21	—	14	14	11	9	8	8	8	27
Extraction	High	240	22	9	12	11	6	8	8	8	11	27
Extraction	Combi'tion	278	25	1	6	16	9	12	10	6	8	32
Commercial	Extraction	231	21	2	10	15	12	12	11	6	8	24
Commercial	Commercial	296	22	—	10	15	14	10	10	5	8	27
Commercial	High	220	19	11	7	10	8	9	8	8	8	31
Commercial	Combi'tion	238	22	1	7	12	14	13	12	6	9	25
Shoot-in-bud	Extraction	251	23	1	12	11	14	14	9	7	7	25
Shoot-in-bud	Commercial	246	22	—	10	16	12	10	10	6	9	26
Shoot-in-bud	High	219	21	9	14	10	8	9	6	6	9	26
Shoot-in-bud	Combi'tion	259	20	—	10	15	13	15	11	4	7	25

Effect of Summer and Fall Pinching on Shift of Production

Experiments were started in 1952 to study the effects of time of pinching on flower production. Cuttings of the variety William Sim were stuck in the propagation medium February 16, planted in a steam-sterilized mixture of 3 parts soil and 1 part manure in 3-inch asphalt bands in mid-March, and given the first pinch in the period April 4 to April 11. On May 28 the plants were benched 8 × 8 inches in 12 plots. A total of 1,188 plants were used. The shoots that developed after the first pinch were again pinched when they had developed so that there were six or seven clearly visible internodes. About five sets of leaves were left below each pinch. Shoots on all plants were pinched in this manner until mid-July.

Flower production of plants receiving no further pinching was compared with flower production from separate lots of plants that were pinched either August 15, September 15, October 15, November 15, December 15, or January 15. The only shoots that were pinched at these times were those that had a flower bud visible. The pinch was made at such a height that about six sets of leaves remained on the stem. These stems were tagged, and each shoot that developed subsequently from these pinched stems was tagged.

TABLE 7.—The yearly flower production as affected by various types of pinches. First pinch made May 8, variety Northland, 1951-1952

Type of pinch		Total no. of flowers	Ave. no. of flowers per sq. ft.	Flower production expressed as percentage distribution by month								
First	Succeeding			Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Extraction	Extraction	280	22	—	14	7	13	10	8	7	10	30
Extraction	Commercial	246	18	1	18	9	10	10	6	6	12	27
Extraction	High	246	18	2	17	10	7	5	6	8	11	34
Extraction	Combi'tion	258	19	—	9	13	13	14	7	5	7	30
Commercial	Extraction	311	22	—	9	14	13	12	9	5	6	31
Commercial	Commercial	302	23	1	10	15	10	10	8	8	6	31
Commercial	High	275	20	13	14	8	7	6	5	7	8	29
Commercial	Combi'tion	279	20	—	5	15	17	13	8	5	7	29
Shoot-in-bud	Extraction	268	20	—	12	15	15	11	9	5	7	24
Shoot-in-bud	Commercial	243	23	1	15	15	14	7	6	5	6	29
Shoot-in-bud	High	249	18	10	16	12	8	7	6	5	7	28
Shoot-in-bud	Combi'tion	249	18	—	6	17	15	13	8	5	6	30

The practice of pinching stems bearing visible flower buds markedly reduced flower production for 1 to 3 months afterwards depending on the time of the year (Table 10). The shoots that developed from these pinched stems increased the flower production later in the season.

TABLE 8.—The flower production of terminal shoots from a July 17 pinch. First pinch made April 16, variety Northland, 1951-1952

Type of pinch		Total number of flowers	Flower production expressed as percentage distribution by month						
First	Succeeding		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Extraction	Extraction	31	7.5	48.5	25.5	13.5	3.0	2.5	2.0
Extraction	Commercial	20	1.0	42.0	31.5	20.5	2.0	2.0	0.0
Extraction	High	20	15.0	62.5	17.5	2.5	0.0	0.0	0.0
Extraction	Combination	48	9.5	46.0	20.5	18.5	5.5	1.5	0.0
Commercial	Extraction	22	11.0	19.0	38.0	20.5	3.0	3.0	3.0
Commercial	Commercial	24	0.0	32.0	36.8	21.0	10.0	0.0	0.0
Commercial	High	25	10.5	63.0	24.5	0.0	0.0	0.0	0.0
Commercial	Combination	59	14.0	37.5	25.0	17.5	2.5	0.0	0.0
Shoot-in-bud	Extraction	37	9.0	23.0	37.0	22.5	12.5	0.0	0.0
Shoot-in-bud	Commercial	35	1.5	29.5	36.5	22.5	8.5	0.0	0.0
Shoot-in-bud	High	26	12.5	50.5	28.0	5.5	0.0	0.0	0.0
Shoot-in-bud	Combination	58	10.0	45.5	31.0	10.5	4.0	0.0	0.0

TABLE 9.—The flower production of terminal shoots from a July 17 pinch. First pinch made May 8, variety Northland, 1951-1952

Type of pinch		Total number of flowers	Flower production expressed as percentage distribution by month						
First	Succeeding		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Extraction	Extraction	34	3.0	22.0	47.5	21.0	3.0	0.0	0.0
Extraction	Commercial	25	0.0	26.0	39.5	35.0	4.0	0.0	0.0
Extraction	High	9	0.0	44.0	56.5	0.0	0.0	0.0	0.0
Extraction	Combination	44	6.5	41.0	30.5	21.5	0.0	0.0	0.0
Commercial	Extraction	49	2.0	47.0	35.0	15.5	1.0	0.0	0.0
Commercial	Commercial	48	0.0	53.0	38.5	6.5	0.0	0.0	0.0
Commercial	High	22	4.5	50.0	43.0	2.5	0.0	0.0	0.0
Commercial	Combination	68	5.0	35.5	36.0	19.5	3.0	0.0	0.0
Shoot-in-bud	Extraction	37	1.0	31.0	46.0	15.5	1.0	1.0	0.0
Shoot-in bud	Commercial	27	0.0	26.0	66.5	8.0	0.0	0.0	0.0
Shoot-in bud	High	25	4.0	55.0	30.0	10.5	0.0	0.0	0.0
Shoot-in-bud	Combination	45	2.5	54 5	28.5	12.5	0.0	2.0	0.0

In making comparison between columns, it should be borne in mind that the usual commercial practice is to pinch on July 15. There were not a large number of pinches made on August 15 and the differences in the results were not great. Production was decreased in August and September and increased only about 2 percent from October through January. The results from the September 15 pinch are striking in that September and October production was low, but there was an increase of about 14 percent in May when compared with plants pinched July 15.

Whether the pinch was made either on October 15, November 15, December 15, or January 15, the increase in production came in June, and there was about a 10 percent increase in each instance.

The data in Table 11 show that a high percentage of stems pinched August 15 produced flowers from December through April. Flower production from stems pinched September 15 was high in the period April through June. The stems pinched October 15 and later did not produce flowers in large numbers until June.

TABLE 10.—The total flower production per year as affected by various times of pinching, variety William Sim, 1952-1953

Month of production	Total flower production expressed as percentage distribution by month when stems were pinched on						
	July 15	Aug. 15	Sept. 15	Oct. 15	Nov. 15	Dec. 15	Jan. 15
August	1.0	——	0.9	1.6	1.5	1.3	1.1
September	14.4	9.6	7.2	17.0	16.9	14.8	13.0
October	14.5	16.0	0.2	7.7	14.0	15.2	12.2
November	5.0	7.5	6.7	0.1	2.5	6.8	5.2
December	5.2	6.4	5.1	0.7	——	1.3	5.2
January	4.3	6.5	5.7	3.6	——	——	2.2
February	4.6	4.5	5.6	3.8	0.8	——	——
March	5.2	4.8	5.0	6.7	4.5	1.6	——
April	5.0	4.1	8.2	5.1	3.6	3.8	1.9
May	14.4	11.7	28.2	16.7	18.2	17.0	20.8
June	26.5	29.0	27.2	37.0	37.1	38.3	37.4
Total number of flowers produced	1413	1354	1186	1206	1133	1246	1411
Flower production per sq. ft. per year	32.1	30.8	27.0	28.2	27.4	28.9	32.1

TABLE 11.—Flower production from stems pinched at various times of the year, variety William Sim, 1952-1953

Month of production	Flower production expressed as percentage distribution by month when stems were pinched on					
	Aug. 15	Sept. 15	Oct. 15	Nov. 15	Dec. 15	Jan. 15
November	4.3	——	——	——	——	——
December	16.5	0.4	——	——	——	——
January	15.8	0.6	——	——	——	——
February	16.5	1.7	——	——	——	——
March	21.6	4.4	——	——	——	——
April	15.1	12.0	——	——	0.7	——
May	7.2	51.6	11.1	5.4	5.1	3.3
June	2.9	29.2	88.9	94.6	94.2	96.7
Number of pinches made	88	316	219	192	176	187
Number of flowers produced from pinched stems	139	517	225	148	137	123

Crop Control for 2-year Culture

Five plots of 150 plants each were used for a study in 1953-1954 of the effect of pinching at various times on flower production in the second year. Production from plants in continuous flowering was compared with production from separate lots of plants in which stems bearing visible flower buds were pinched May 15, June 15, or July 15. In addition, comparisons were made with two other lots of plants in which the stems with visible flower buds were allowed to remain, but in one lot the less developed stems were pinched on May 15 and July 15, and with the other lot on June 15 and July 15.

The data in Table 12 show that all methods of pinching not only reduced the total number of flowers produced, but also caused some shift in time of production. Stems pinched May 15 produced shoots that flowered largely from October through February; stems pinched

TABLE 12.—The total flower production for the second year as affected by various times of pinching, variety William Sim, 1953-1954

Month of production	Total flower production expressed as percentage distribution by month from stems pinched on					
	July 15 1952*	May 15 1953	June 15 1953	July 15 1953	May 15 1953 and July 15 1953	June 15 1953 and July 15 1953
July	9.0	11.6	2.3	8.8	1.5	6.5
August	7.5	6.7	8.3	4.9	0.4	——
September	8.0	9.0	8.1	9.2	7.7	1.5
October	5.0	7.1	3.5	5.1	12.3	5.0
November	4.0	7.1	4.4	4.5	11.4	10.5
December	5.6	5.2	7.1	7.1	10.5	13.0
January	5.6	5.2	7.0	6.5	7.5	14.0
February	10.4	8.8	7.4	11.0	8.0	11.5
March	7.0	5.6	10.8	5.5	5.5	5.5
April	8.5	7.0	6.3	7.1	5.6	5.0
May	8.8	10.0	11.4	12.0	9.1	11.0
June	20.5	18.0	17.9	18.3	20.4	16.4
Total flower production	1896	1485	1679	1572	1443	1248
Flower production per square foot per year	43.1	34.9	38.2	35.7	32.8	29.3

*These plants were not pinched in 1953, flowering was continuous.

June 15 produced shoots that flowered mainly in the period from December through February; flower production was increased from January through June by shoots from stems pinched July 15. Stems pinched May 15 and July 15 produced flowering shoots in considerable number from September through February; and the stems pinched June 15 and July 15 caused increased production from November through February.

Late Summer and Early Fall Pinching

Since it had been shown that pinching shoots in late summer and early fall (Table 10 and 11) increased production from December through May, a study was started in 1953 in which plants of the variety Sydney Littlefield and William Sim were propagated in March, placed in a steamed mixture of 3 parts soil and 1 part manure in 3-inch asphalt bands April 1, and given the first pinch about May 1. The plants were benched 8 × 8 inches June 1 and the last general pinch was made on July 8. Thereafter, rapidly developing shoots were pinched when flower buds became visible, until September 15.

TABLE 13.—Second year flower production from stems pinched at various times of the year, variety William Sim, 1953-1954

Month of production	Flower production expressed as percentage distribution by month from stems pinched on				
	May 15	June 15	July 15	May 15 and July 15	June 15 and July 15
September	6.3	——	——	14.7	——
October	16.3	4.4	5.2	15.5	4.6
November	23.5	8.2	5.2	13.3	13.9
December	17.2	18.1	6.2	15.3	21.9
January	11.8	26.9	12.4	9.5	19.9
February	15.4	16.5	26.8	11.9	14.2
March	3.6	5.5	13.4	4.8	5.3
April	——	2.2	9.3	2.6	5.0
May	1.8	4.4	12.4	3.4	7.9
June	4.1	13.7	9.3	8.9	7.3
Number of pinches made	392	348	106	668	372
Number of flowers produced from stems pinched	221	182	97	503	302

The data in Table 14 show that this method of continuous pinching until early fall provided high flower production in the period from February through June.

TABLE 14.—Yearly flower production as affected by continuous pinching until September 15, varieties Sydney Littlefield and William Sim, 1953-1954

Month of production	Flower production expressed as percentage distribution by month	
	Sydney Littlefield	William Sim
October	0.1	——
November	5.6	0.7
December	7.9	4.7
January	6.4	6.0
February	12.7	14.4
March	14.8	18.7
April	15.7	17.5
May	13.1	11.0
June	23.8	21.2
Total flower production	8312	9888
Flower production per square foot per year	23.7	31.2

SINGLE PINCHING

Preliminary trials of the single pinch method of culture were made in 1951 and 1952. Six plantings were made at 2-week intervals from May 15 to August 1. This exploratory work indicated that information was needed on single pinch culture when used at various times of the year. The following year, plantings of the variety Apollo were made at about 6-week intervals. A 6 × 6 inch spacing was used, and the plants were pinched 1 month after planting. Table 15 gives flower production in the 12-month period following planting.

Peak production occurred as early as 3 to 4 months after pinching the plants benched in spring and as long as 7 or 8 months after pinching the plants benched in the fall. The first crop of flowers was cut off in as short a period as 2 to 3 months for plants pinched in winter and spring, but extended for as long a period as 7 to 8 months for the plants pinched July 1.

Flower production per square foot varied considerably depending on the time of year the plants were in production. Flower production was more rapid in the summer months, and, in general, when the 12-month period after planting encompassed the summer months, higher total production was realized (Table 15).

Effect of Pruning on Cropping

Another single-pinch culture study was designed to determine the effect of limiting the number of stems per plant on the rate of floral development. Plantings of the variety Apollo were made every 2 weeks from May 15 to July 15, and four pruning treatments were used. One lot of plants in each planting was not pruned; the other three lots were

TABLE 15.—Flower production in the 12-month period following planting with the single pinch method of culture, variety Apollo, 1952-1953

Month of production	Flower production expressed as percentage distribution by month from plants pinched								
	Feb 1	Mar. 1	Apr. 1	June 1	July 1	Sept. 1	Oct. 1	Nov. 15	Jan. 1
May	——	——	——	——	——	——	——	——	——
June	28.7	2.7	——	——	——	——	——	——	——
July	29 8*	40.7	33.2	——	——	——	——	——	——
August	5.5	8.3*	11.1	18.1	——	——	——	——	——
September	3.1	9.5	9.1*	22.0	5.6	——	——	——	——
October	3.8	8.6	9.4	13.9	12.8	——	——	——	——
November	12.1	8.9	6.5	3.9	9.2	——	——	——	——
December	17.0	8.6	5.5	2.7	8.7	——	——	——	——
January	——	12.8	7.5	1.9*	13.8	0.3	——	——	——
February	——	——	11.7	5.0	6.7	5.5	——	——	——
March	——	——	5.9	8.5	9.7	24.9	1.2	——	——
April	——	——	——	23.9	16.4	16.6	15.2	——	——
May	——	——	——	——	16.9*	5.8*	31.3	18.8	1.5
June	——	——	——	——	——	13.2	27.0*	40.2*	48.5
July	——	——	——	——	——	33.5	13.7	8.7	12.1
August	——	——	——	——	——	——	11.7	5.4	6.8
September	——	——	——	——	——	——	——	15.2	9.1
October	——	——	——	——	——	——	——	11.6	7.6
November	——	——	——	——	——	——	——	——	14.4
Total flower production	906	1298	1184	994	648	967	851	853	1020
Flower production per sq. ft. per year	28.9	33.7	30.7	25.9	19.5	32.5	25.6	27.6	26.4

*Indicates month of the end of the first crop.

pruned to 4, 3, and 2 stems respectively per plant. The plants were spaced so that each flowering stem was allowed 4 square inches of bench space.

Table 16 gives the flower production from the time of planting through June. There were some differences among the plantings, but in general the rate of development of the flowers was the same from the plants whether pruned or not.

TABLE 16.—Flower production from pruned plants with the single pinch method of culture, variety Apollo, 1952-1953

Month of production	Flower production expressed as percentage distribution per month from stems pinched on June 15			
	No. stems per plant			
	Not pruned	4	3	2
August	5.5	9.2	8.5	11.7
September	22.1	18.8	21.7	18.1
October	8.0	4.6	3.8	2.6
November	2.1	0.8	0.7	0.6
December	*1.0	0.7	1.0	0.3
January	0.6	*0.8	*0.6	*1.3
February	0.8	1.4	1.4	2.5
March	6.2	9.2	7.5	9.7
April	10.2	10.4	10.6	13.9
May	11.8	9.0	13.6	13.2
June	30.9	35.2	30.5	26.1
Total flower production	1294	1424	1277	1398
Flower production per sq. ft. per yr.	41.7	45.5	43.7	45.2
Month of production	**July 1**			
	No. stems per plant			
	Not pruned	4	3	2
August	1.1	0.8	1.2	0.3
September	16.7	16.7	16.4	15.6
October	9.7	11.3	11.3	12.0
November	7.2	5.7	5.1	4.8
December	4.2	4.1	2.5	2.5
January	4.1	3.2	2.1	1.4
February	*2.4	2.4	2.4	*2.1
March	3.2	*4.7	3.3	4.9
April	3.4	4.2	4.5	4.8
May	9.1	12.1	16.4	16.4
June	38.8	34.9	34.9	35.5
Total flower production	1113	1075	1168	1195
Flower production per sq. ft. per yr.	35.9	34.9	38.9	41.6

Month of production	July 15			
	No. stems per plant			
	Not pruned	4	3	2
August	———	———	———	———
September	1.9	1.0	3.0	2.3
October	10.1	11.0	14.4	15.0
November	13.9	11.0	12.9	13.7
December	10.0	10.7	6.6	6.6
January	5.5	5.6	3.0	2.8
February	3.1	3.3	1.7	1.2
March	3.8	5.2	2.2	*2.1
April	*3.4	5.6	*2.3	2.4
May	10.7	*11.5	13.8	15.2
June	37.5	35.1	40.2	38.8
Total flower production	968	917	1022	1133
Flower production per sq. ft. per yr.	31.7	29.1	35.7	37.0

Month of production	August 1			
	No. stems per plant			
	Not pruned	4	3	2
August	———	———	———	———
September	———	———	0.1	———
October	4.5	3.4	1.8	2.2
November	6.5	7.4	6.8	7.6
December	12.4	9.7	11.0	14.2
January	10.2	9.5	13.0	9.4
February	8.1	6.7	8.7	5.8
March	6.9	9.6	6.1	5.4
April	6.4	4.3	5.2	5.8
May	*13.9	*15.6	*18.0	*17.1
June	31.0	33.7	29.3	32.4
Total flower production	840	852	851	829
Flower production per sq. ft. per yr.	27.5	27 5	28.8	28.2

Month of production	August 15			
	No. stems per plant			
	Not pruned	4	3	2
August	———	———	———	———
September	———	———	———	———
October	0.1	———	———	0.1
November	0.2	0.3	0.7	0.4
December	2.8	4.8	5.1	6.3
January	17.0	17.3	19.3	22.2
February	18.4	15.3	15.1	12.7
March	11.4	7.3	4.7	5.5
April	3.9	2.3	4.1	1.1
May	*11.5	*17.1	*18.9	*19.5
June	34.7	35.8	32.0	32.2
Total flower production	819	797	760	856
Flower production per sq. ft. per yr.	26.0	25.3	25.3	27.3

*Indicates month of the end of the first crop.

The first crop was cut off in as short a period as 6 months for the plants pinched June 15, and as long as 8 months for the plants pinched either July 15 or August 1. In general, there was little difference in flower production per square foot between plants given the various pruning treatments.

FLORAL INITIATION AND DEVELOPMENT IN THE CARNATION

From the preceding tests it was evident that from any given pinch date, there was a considerable period between the time of cutting the first and last flower. Studies were undertaken to discover if variability in the formation and development of flowers was responsible for such differences in time of maturity.

Seasonal Variations in the Development of Northland Flowers

The objective of the first study was the determination of the approximate time of floral initiation and the rate of floral development in the carnation. Approximately 900 Northland plants were propagated May 15, 1953, and then placed in a steamed mixture of 3 parts soil and 1 part manure in 3-inch bands. The plants were pinched in August and then planted 8 × 8 inches in raised benches. They were pinched periodically during the fall leaving five pairs of leaves on the stem.

Starting February 25, 1954, and every 2 weeks thereafter through April 23, 1954, a series of pinching treatments was initiated. On each of these dates 300 shoots were pinched which exhibited a minimum of six or seven clearly visible internodes without visible lateral or axillary shoot development. This was accomplished by snapping out the stem tip leaving approximately five sets of leaves. At the time the stems were pinched, a tag indicating the date of pinching was placed on the remaining portion of the stem. Throughout this entire period of pinching all stems more advanced in development were pinched but were not included in the study.

Four weeks after pinching and at 2-week intervals thereafter through the 18th week, 15 tagged terminal stems were removed from the plants for examination. These stems were removed from consecutive plants in the bench.

The length of each stem was measured and the number of internodes counted. The stem measurement was made from the base of the stem to the growing point. The stem apices were dissected by hand, using a razor blade, and then were examined under 30x magnification to observe the stage of development. Four stages of stem apex developments were selected for the purpose of classification.

On September 24, 1954, 97 plants were removed from the benches, and the internodes were counted on the stems that had macroscopically visible flower buds. Preliminary observations had indicated that the stems that arose from the base of the plant had a greater number of internodes than the stems that were present at the top of the plant.

Fig. 1. Stage I. Vegetative stem apex.

The primary characteristic of this stage is the blunt or rounded apical meristem. This zone was composed of small, closely-packed meristematic cells. Just below the apical meristem there are 3 to 4 very short internodes with primordia at the nodes. Below this zone, cell enlargement is more pronounced as the internodes began to increase greatly in length and diameter.

As the stems were removed from the plants, they were classified as to position on the plant from which they were removed, i. e. base, mid-portion, or top. A total of 448 stems were examined.

Four stages of stem apex development of the carnation variety Northland were selected that ranged from the vegetative stage to advanced stages of flowering (Figures 1 through 6).

Fig. 2. Stage II. Elongation and floral initiation.

This period of development is characterized by a pronounced elongation of the terminal 3 to 4 internodes. This rapid elongation is a marked change from the blunt or rounded apical meristem characteristic of Stage I. Floral initiation has occurred at this stage of development or follows immediately.

Evidence of other than vegetative development in the stem apices was observed for the first time 10 weeks after pinching. In succeeding examinations a progression was noted from Stage I to Stage II to Stage III, etc. At the 16th week after pinching, 50 percent or more of the stem apices were in Stage II or beyond. There was considerable variability in the rate of floral initiation and development. At the 16th

Fig. 3. Stage III. Early floral development in the stem apex.

Floral development can be observed under 30X magnification. There is further elongation of the internodes immediately below the apex.

week, from 20 to 50 percent of the stem had not initiated flowers, but from 9 to 20 percent were in Stage IV. In the 18th examination week all stages were represented from the vegetative to the advanced stages of floral development (Table 17).

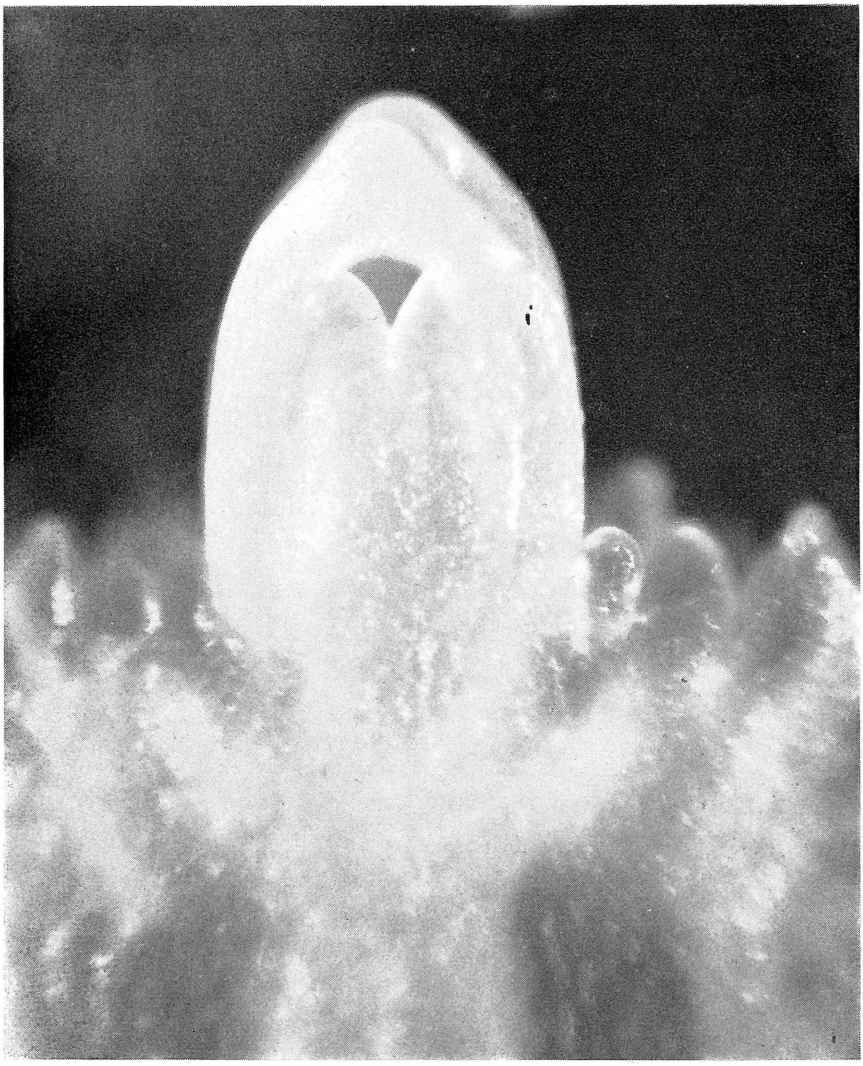

Fig. 4. Stage IVa. Advanced floral development in the stem apex.

At this stage the flower bud is small and cannot be seen without dissection. Under 30X magnification the pistil and other floral parts can be distinguished.

It was necessary to use the median in presenting the stem length data because the extremes deviated so much from the means. In general, the relationship was that the more advanced the stage of floral initiation or development, the longer the stem. There was overlapping between stages and certainly no definite length limitation could be established for each stage of development (Table 18).

The mean number of internodes observed in stems at Stage I did not exceed 14.3. Stems in Stage II development were observed to have from 14.0 to 17.0 internodes. At Stage III and IV a, b, and c the stems had 17.0 to 19.5 internodes (Table 19). The macroscopic examination of stems in Stages IV b and IV c showed that there was a difference of six to seven internodes between stems originating at the top of the plant and those arising at the mid and basal portions of the plant (Table 20).

The Rate of Floral Initiation and Development with the Varieties Sydney Littlefield and White Sim

A study was initiated in 1954 to further investigate stem apex development. It was desired to make observations at various times of the year on plants of the varieties Sydney Littlefield and White Sim.

Fig. 5. Stage IVb. Visible flower bud stage.

Cuttings were rooted in March and then placed in a steamed mixture of 3 parts soil and 1 part manure in 3-inch bands until they were benched 8 × 8 inches in late May. There were about 600 plants of each variety involved in the test.

The first pinch was made the 3rd of May, and subsequently, the developing lateral stems which exhibited a minimum of five or six clearly visible internodes were pinched until mid-July. The stems pinched July 17 were identified with a dated tag. On August 20 and September 16 stems bearing a visible flower bud were pinched at such a manner that the remaining stem had five or six sets of leaves. Dated tags were placed on these stems.

Fig. 6. Stage IVc. Flower at anthesis or ready for cutting.

TABLE 17.—The stage of stem apex development expressed as percentage of total stems examined on each date, variety Northland, 1953-1954

Date of pinch	Percentage of stems in various stages of development* at different time intervals after pinching					
	10 weeks					
	I	II	III	IVa	b	c
February 25	100	—	—	—	—	—
March 11	100	—	—	—	—	—
March 25	100	—	—	—	—	—
April 8	100	—	—	—	—	—
April 23	87	13	—	—	—	—
Date of pinch	**12 weeks**					
	I	II	III	IVa	b	c
February 25	93	7	—	—	—	—
March 11	100	—	—	—	—	—
March 25	93	7	—	—	—	—
April 8	87	13	—	—	—	—
April 23	60	40	—	—	—	—
Date of pinch	**14 weeks**					
	I	II	III	IVa	b	c
February 25	75	25	—	—	—	—
March 11	60	33	—	7	—	—
March 25	73	20	—	7	—	—
April 8	53	33	7	7	—	—
April 23	60	33	7	—	—	—
Date of pinch	**16 weeks**					
	I	II	III	IVa	b	c
February 25	20	27	33	20	—	—
March 11	27	54	9	9	—	—
March 25	50	31	20	—	—	—
April 8	25	13	31	13	20	—
April 23	33	33	7	13	13	—
Date of pinch	**18 weeks**					
	I	II	III	IVa	b	c
February 25	†	†	†	†	†	†
March 11	†	†	†	†	†	†
March 25	20	27	20	20	13	—
April 8	7	13	27	—	53	—
April 23	6	18	12	12	35	18

*For description of stages see Figures 1 through 6.

†No sample

TABLE 18.—Median stem length at various stage of development, variety Northland, 1953-1954

Date of pinch	Length of stems in millimeters at different stages of stem development* at various weeks from pinching to sampling					
	10 weeks					
	I	II	III	IVa	b	c
February 25	85	—	—	—	—	—
March 11	85	—	—	—	—	—
March 25	46	—	—	—	—	—
April 8	57	—	—	—	—	—
April 23	80	135	—	—	—	—
Date of pinch	**12 weeks**					
	I	II	III	IVa	b	c
February 25	95	130	—	—	—	—
March 11	115	—	—	—	—	—
March 25	85	135	—	—	—	—
April 8	92	126	—	—	—	—
April 23	115	160	—	—	—	—
Date of pinch	**14 weeks**					
	I	II	III	IVa	b	c
February 25	160	165	—	—	—	—
March 11	180	230	—	255	—	—
March 25	100	160	—	380	—	—
April 8	115	150	205	260	—	—
April 23	130	140	145	—	—	—
Date of pinch	**16 weeks**					
	I	II	III	IVa	b	c
February 25	180	240	230	360	—	—
March 11	155	140	205	325	—	—
March 25	85	85	200	—	—	—
April 8	75	155	235	230	380	—
April 23	80	145	250	345	415	—
Date of pinch	**18 weeks**					
	I	II	III	IVa	b	c
February 25	†	†	†	†	†	†
March 11	†	†	†	†	†	†
March 25	65	120	120	310	380	—
April 8	90	170	220	—	400	—
April 23	100	135	315	310	410	440

*For description of stages see Figures 1 through 6.

†No sample.

TABLE 19.—Mean number of internodes per stem at various stages of development, variety Northland, 1953-1954

Date of pinch	Number of internodes at different stages of stem development* at various weeks from pinching to sampling					
	10 weeks					
	I	II	III	IVa	b	c
February 25	10.6	——	——	——	——	——
March 11	10.5	——	——	——	——	——
March 25	10.1	——	——	——	——	——
April 8	10.8	——	——	——	——	——
April 23	10.4	14.0	——	——	——	——
Date of pinch	**12 weeks**					
	I	II	III	IVa	b	c
February 25	11.7	14.0	——	——	——	——
March 11	12.1	——	——	——	——	——
March 25	11.2	15.0	——	——	——	——
April 8	12.3	14.0	——	——	——	——
April 23	12.2	14.5	——	——	——	——
Date of pinch	**14 weeks**					
	I	II	III	IVa	b	c
February 25	12.9	14.8	——	——	——	——
March 11	13.2	15.0	——	17.0	——	——
March 25	13.2	14.7	——	18.0	——	——
April 8	13.0	14.8	18.0	18.0	——	——
April 23	13.4	14.4	18.0	——	——	——
Date of pinch	**16 weeks**					
	I	II	III	IVa	b	c
February 25	14.3	15.8	17.3	17.8	——	——
March 11	13.2	15.8	17.5	19.0	——	——
March 25	12.9	16.0	17.7	——	——	——
April 8	12.8	14.5	17.8	17.5	18.0	——
April 23	12.6	16.0	18.0	18.0	17.5	——
Date of pinch	**18 weeks**					
	I	II	III	IVa	b	c
February 25	†	†	†	†	†	†
March 11	†	†	†	†	†	†
March 25	12.3	16.5	18.7	19.0	18.0	——
April 8	13.0	16.0	18.0	——	19.1	——
April 23	14.0	17.0	19.5	19.0	18.7	18.0

*For description of stages see Figures 1 through 6.

†No sample.

TABLE 20.—Mean number of internodes at stages IV b and IV c based on point of origin of the stem in the plant

Point of Origin	Number of Internodes
Base	24 2
Mid	23.2
Top	17.2

When shoots developed from the pinched stems, they were classified as to point of origin, i. e., from the basal, middle, or top portions of the plant (Figure 7). The shoots that developed on stems pinched July 17 originated from the middle portion of the plant. Shoots from the August 20 and September 16 pinches came from the top portions of the plant. The basal shoots originated from the lower part of the plant.

At periods from 8 to 26 weeks after pinching, samples of terminal shoots were taken from stems pinched on the various dates, and the stem apices were dissected and stage of development noted under 30x magnification. The stem length, the number of internodes, and the number of visible leaves were recorded.

In addition, shoots that had been tagged at the three pinch dates but were not subsequently used as samples, were removed from the plant at maturity and the stem length and the number of internodes were recorded.

The data in Tables 21 and 22 show that floral initiation had occurred in terminal shoots from the stems pinched in July and August in less than 14 weeks after the pinch; in fact, on the date of observation at the 14th week, 50 to 75 percent of the shoots had developed externally visible flower buds. Over 50 percent of the shoots from the September pinch, however, were still in the vegetative state. It was not until the 26th week after the pinch that more than 50 percent of the shoots developing from the September pinch exhibited externally visible flower buds.

There were only minor differences between the stage of development of the shoots of the varieties Sydney Littlefield and White Sim from stems pinched in July, August, and September, but there was some evidence that the rate of initiation was more rapid in the basal shoots of the variety White Sim than in the basal shoots of the variety Sydney Littlefield.

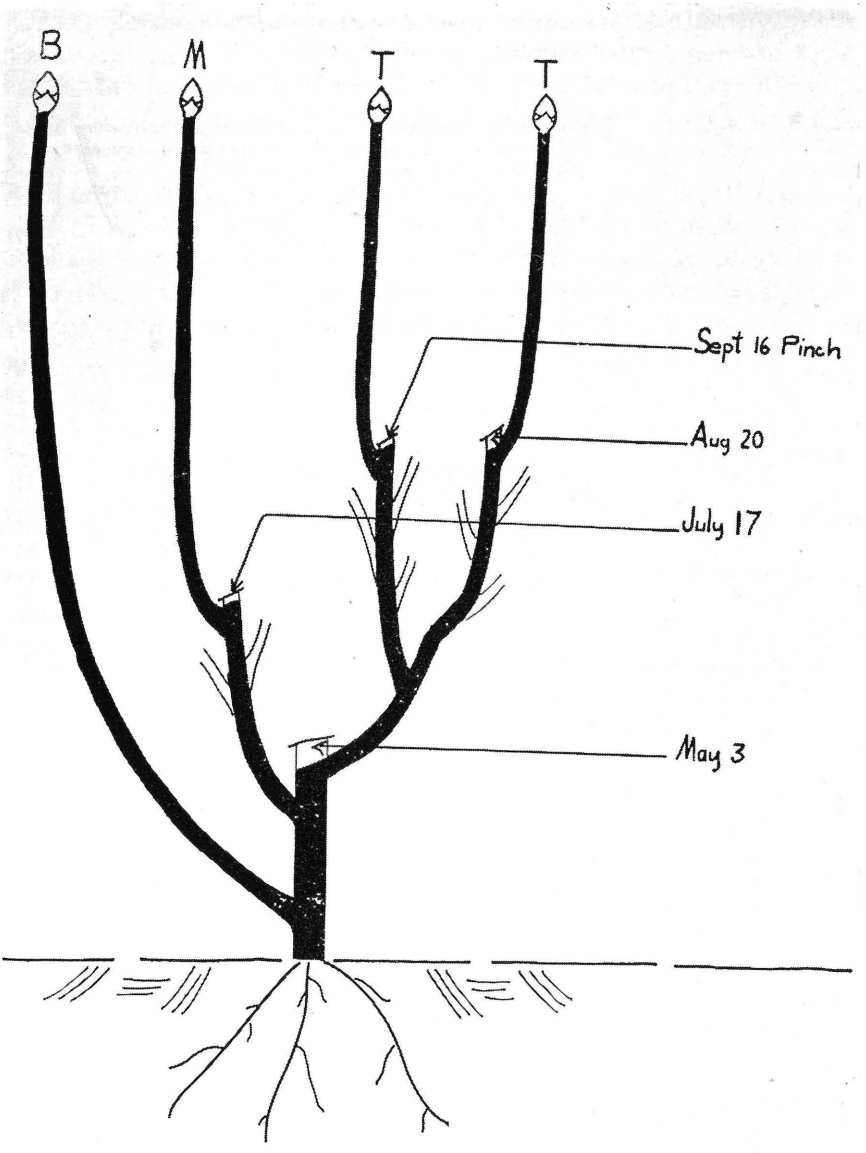

Fig. 7. Structure of a multiple pinched plant.

B. Shoot originating from the basal portion of the plant and not pinched.

M. Shoot originating from the middle portion of plant.

T. Shoot originating from the top portion of plant.

TABLE 21.—Stage of development of the stem apex, variety Sydney Littlefield, 1954-1955

Time of pinch	Time of observation in weeks after pinch	Number of stems observed	Percentage distribution by stage of development*				
			I	II	III	IV a	IV b
July 17	14	60	2	—	10	13	75
	18	60	—	3	3	12	82
	22	59	3	3	—	5	89
August 20	10	59	15	12	32	27	14
	14	53	2	2	3	18	75
September 16	8	60	90	7	3	—	—
	10	60	64	17	8	8	3
	14	120	58	6	7	16	13
	18	60	42	5	7	10	36
	22	40	18	8	12	12	50
	26	40	10	3	15	20	52
May or June (basal shoots)	18–22	15	40	27	13	20	20
	22–26	15	47	—	20	—	33
	26–30	15	40	—	—	27	33
	30–34	15	20	—	7	7	66

*For description of stages see Figures 1 through 6.

Throughout the 12-week observation period, 20 to 47 percent of the basal shoots of plants of Sydney Littlefield and 7 to 20 percent of the basal shoots of plants of White Sim were in the vegetative stage of development. There did not appear to be a marked increase in floral initiation during the observation period. The basal shoots initiated and developed slower than the terminal shoots from the pinched stems.

The general range for the number of internodes on shoots pinched after floral initiation from July through September was 14 to 21 for either variety. The basal shoots produced a greater number of internodes before flowering; it varied from 16 to 28 for either variety (Tables 23 and 25). The later the date of observation the greater the number of internodes. For example, shoots in Stage II or farther advanced which had developed from stems pinched in September, had as few internodes as 14.5 on the 8th week examination, and on the 26th week examination they had as many as 22.0 internodes.

The data of Tables 24 and 26 show that about 75 percent of the shoots from stems pinched in July, August, and September had more than 15 but less than 20 internodes in Stage II or in farther advanced stages. Twenty percent or less of the stems in Stage I development had 15 internodes or more.

The basal shoots formed more internodes before floral initiation occurred as indicated by the fact that 84 to 100 percent of the stems in Stage I development had 15 or more internodes while none of the basal shoots that were at or beyond Stage II in development had less than 15 internodes although 85.4 to 97.4 percent of them had 20 internodes or more.

TABLE 22.—Stage of development of stem apex, variety White Sim, 1954-1955

Time of pinch	Time of observation in weeks after pinch	Number of stems observed	Percentage distribution by stage of development*				
			I	II	III	IV a	IV b
July 17	14	60	7	3	22	18	50
	18	59	3	—	8	8	8
	22	57	2	3	2	14	79
August 20	10	50	16	7	17	30	30
	14	60	2	2	5	31	60
	18	60	2	3	—	12	83
	22	40	—	3	—	—	97
September 16	8	60	82	7	3	8	—
	10	60	70	13	12	3	2
	14	120	55	4	10	14	17
	18	60	42	7	2	8	41
	22	40	30	23	7	7	33
	26	40	5	—	23	20	52
May or June (basal shoots)	18–22	15	7	7	40	20	26
	22–26	10	20	—	20	10	50
	26–30	10	20	10	—	10	60
	30–34	10	20	—	—	—	80

*For description of stages see Figures 1 through 6.

TABLE 23.—Number of internodes per stem, variety Sydney Littlefield, 1954-1955

Time of pinch	Time of observation in weeks after pinch	No. of stems observed	Average number of internodes per stem by stage of development*				
			I	II	III	IV a	IV b
July 17	14	60	14.0(1)†	———	16.6(6)	18.2(8)	18.0(45)
	18	60	———	19.0(2)	20.0(2)	21.0(7)	19.2(49)
	22	59	17.0(2)	19.0(2)	———	21.2(3)	20.0(52)
August 20	10	59	12.3(9)	14.0(7)	15.7(19)	16.4(16)	15.9(8)
	14	53	11.0(1)	15.0(1)	17.5(2)	16.6(10)	15.9(39)
September 16	8	60	11.3(54)	14.5(4)	17.0(2)	———	———
	10	60	12.8(38)	15.3(10)	17.0(5)	16.0(5)	16.5(2)
	14	120	14.2(69)	15.7(8)	16.6(9)	17.3(19)	17.0(15)
	18	60	15.7(25)	18.0(3)	18.0(4)	18.6(6)	16.6(22)
	22	40	17.1(7)	20.3(3)	20.0(5)	21.0(5)	17.6(20)
	26	40	19.0(4)	22.0(1)	20.0(6)	21.3(8)	20.5(21)
May or June (basal shoots)	18–22	15	13.3(3)	16.0(4)	18.5(2)	19.7(3)	10.7(3)
	22–26	15	17.1(7)	———	22.7(3)	———	22.0(5)
	26–30	15	18.1(6)	———	———	24.5(4)	24.6(5)
	30–34	15	21.0(3)	———	24.0(1)	27.0(1)	22.3(10)

*For description of stages see Figures 1 through 6.
†Figures in parentheses refer to number of stems examined.

TABLE 24.—Percentage distribution of extremes in number of internodes, variety Sydney Littlefield, 1954-1955

Terminal stems from July, August, and September pinches	
Total number at Stage I development	210
Percentage of stems with 15 internodes or more	18.1 %
Total number at Stage II development or beyond	461
Percentage of stems with 15 internodes or less	4.8 %
Percentage of stems with 20 internodes or more	24.5 %
Basal stems	
Total number at Stage I development	19
Percentage of stems with 15 internodes or more	84.2 %
Total number at Stage II development or beyond	41
Percentage of stems with 15 internodes or less	0.0 %
Percentage of stems with 20 internodes or more	85.4 %

TABLE 25.—Number of internodes per stem, variety White Sim, 1954-1955

Time of pinch	Time of observation in weeks after pinch	No. of stems observed	Average number of internodes per stem by stage of development*				
			I	II	III	IV a	IV b
July 17	14	60	12.5(4)†	15.0(2)	16.6(13)	18.4(11)	17.8(30)
	18	59	16.0(2)	———	20.0(5)	19.5(5)	19.0(47)
	22	57	14.0(1)	20.0(2)	21.0(1)	21.0(8)	19.1(45)
August 20	10	50	13.0(9)	13.8(5)	15.4(10)	15.7(18)	15.0(18)
	14	60	15.0(1)	15.5(2)	17.7(2)	16.6(19)	15.0(36)
	18	60	15.0(1)	15.5(2)	———	17.5(7)	15.0(50)
	22	40	———	18.9(1)	———	———	17.0(39)
September 16	8	60	12.2(49)	15.0(4)	15.5(2)	16.2(5)	———
	10	60	12.2(42)	14.8(8)	16.0(7)	16.5(2)	15.0(1)
	14	120	13.9(67)	15.8(4)	17.0(12)	16.7(17)	16.0(20)
	18	60	14.8(26)	16.8(3)	19.0(1)	17.0(5)	16.5(25)
	22	40	16.5(13)	19.7(8)	20.3(3)	19.3(3)	17.0(13)
	26	40	18.5(1)	———	20.4(9)	20.9(9)	19.0(21)
May or June (basal shoots)	18–22	15	15.9(1)	18.0(1)	19.5(6)	21.0(3)	21.5(4)
	22–26	10	16.0(2)	———	23.0(2)	23.0(1)	23.6(5)
	26–30	10	19.0(2)	20.0(1)	———	28.0(1)	25.0(6)
	30–34	10	23.0(2)	———	———	———	24.5(8)

*For description of stages see Figures 1 through 6.
†Figures in parenthesis refer to number of stems examined.

TABLE 26.—Percentage distribution of extremes in number of internodes, variety White Sim, 1954-1955

Terminal stems from July, August, and September pinches	
Total number at Stage I development	216
Percentage of stems with 15 internodes or more	20.4 %
Total number at Stage II development or beyond	560
Percentage of stems with 15 internodes or less	15.0 %
Percentage of stems with 20 internodes or more	8.9 %
Basal stems	
Total number at Stage I development	7
Percentage of stems with 15 internodes or more	100.0 %
Total number at Stage II development or beyond	38
Percentage of stems with 15 internodes or less	0.0 %
Percentage of stems with 20 internodes or more	97.4 %

The stem length data in Tables 27 and 28 show that the stems increased in length as they developed from a vegetative stage to maturity; that the stems developing later in the season were longer than those that developed earlier; that the basal stems were generally longer than those originating higher on the plant; and that White Sim stems were longer than those of Sydney Littlefield because of the inherent greater internodal length.

The flowers produced throughout the period of October through May exhibited the same stem length and internodal relationship to the stage of development as noted for the routine samples (Tables 29 and 31). From 75 to 85 percent of the shoots that developed from stems pinched in July, August, and September had more than 15 internodes and less than 20 at the time of flowering. However, 100 percent of the basal shoots had 20 or more internodes at the time of flowering (Tables 30 and 32).

TABLE 27.—Stem length at the various stages of development, variety Sydney Littlefield, 1954-1955

Time of pinch	Time of observation in weeks after pinch	No. of stems observed	Average stem length in centimeters by stage of development*				
			I	II	III	IV a	IV b
July 17	14	60	9.1(1)†	———	31.1(6)	38.0(8)	54.0(45)
	18	60	———	30.0(2)	43.5(2)	47.0(7)	60.0(49)
	22	59	28.4(2)	47.4(2)	———	55.2(3)	67.0(52)
August 20	10	59	13.6(9)	17.8(7)	20.9(19)	33.2(16)	41.2(8)
	14	53	12.5(1)	18.8(1)	28.7(2)	36.7(10)	49.4(39)
September 16	8	60	7.8(54)	15.0(4)	19.5(2)	———	———
	10	60	9.7(38)	16.0(10)	20.0(5)	28.5(5)	43.5(2)
	14	120	10.0(69)	23.4(8)	23.5(9)	32.7(19)	46.0(15)
	18	60	24.2(25)	26.1(3)	30.8(4)	38.6(6)	55.4(22)
	22	40	27.8(7)	32.8(3)	29.8(5)	42.8(5)	57.3(20)
	26	40	24 5(4)	41.0(1)	32.4(6)	49.0(8)	66.2(21)
May or June (basal shoots)	18–22	15	11.3(3)	21.3(4)	21.4(2)	46.6(3)	62.0(3)
	22–26	15	24.2(7)	———	39.0(3)	———	61.8(5)
	26–30	15	27.5(6)	———	———	59.3(4)	77.3(5)
	30–34	15	45.6(3)	———	54.5(1)	82.0(1)	77.4(10)

*For description of stages see Figures 1 through 6.
†Figures in parenthesis refer to number of stems examined.

TABLE 28.—Stem length at the various stages of development, variety White Sim, 1954-1955

Time of pinch	Time of observation in weeks after pinch	No. of stems observed	Average stem length in centimeters by stage of development*				
			I	II	III	IV a	IV b
July 17	14	60	25.0(4)†	26.1(2)	38.7(13)	53 2(11)	75.0(30)
	18	59	40.7(2)	———	48.7(5)	58 4(5)	79.0(49)
	22	57	25.4(1)	61.3(2)	53.5(1)	72 9(8)	84.4(45)
August 20	10	50	21.0(9)	25.5(5)	27.0(10)	38 7(18)	52.3(18)
	14	60	25.5(1)	28.0(2)	36 8(2)	48.5(19)	59.4(36)
	18	60	23.0(1)	32.3(2)	———	56.7(7)	68.0(50)
	22	40	———	40.5(1)	———	———	76.8(39)
September 16	8	60	12.0(49)	18.8(4)	16.3(2)	29.2(5)	———
	10	60	15.7(42)	19.3(8)	22.5(7)	22.0(2)	43.5(1)
	14	120	25.3(67)	29.7(4)	34.6(12)	44 5(17)	64.0(20)
	18	60	32.6(26)	41.4(3)	36.0(1)	54.1(5)	69.0(25)
	22	40	39.0(13)	48.7(8)	52.5(3)	72.2(3)	77.3(13)
	26	40	45.8(2)	———	53 5(9)	65.6(8)	81.3(21)
May or June (basal shoots)	18–22	15	21.3(1)	23.5(1)	38.8(6)	65.6(3)	87.4(4)
	22–26	10	23 2(2)	———	43.0(2)	51 5(1)	88 8(5)
	26–30	10	42.2(2)	50.8(1)	———	63.8(1)	102 6(6)
	30–34	10	48.5(2)	———	———	———	98.4(8)

*For description of stages see Figures 1 through 6.
†Figures in parenthesis refer to number of stems examined.

In another phase of the study some stems of both Sydney Littlefield and White Sim varieties were allowed to flower without removal of the lateral shoots (Figure 8). At the time the terminal flower reached anthesis the stem was removed from the plant at the point of origin and the stem apex development and the number of internodes for each latral shoot was determined. Data in Tables 33 and 34 show that at the time of anthesis of the terminal flower there were flower buds visible (Stage IV b) in the lateral shoots as low as the seventh or eighth node from the terminal flower, and at this point the axillary shoot was vegetative (Stage I). There was an abrupt change from one node to the next one downward from advanced floral development to the vegetative stage. The lateral shoots that had developed flower buds at that time had from three to six internodes. The first vegetative shoot had nine internodes at that time and later had 17 internodes at the time it flowered.

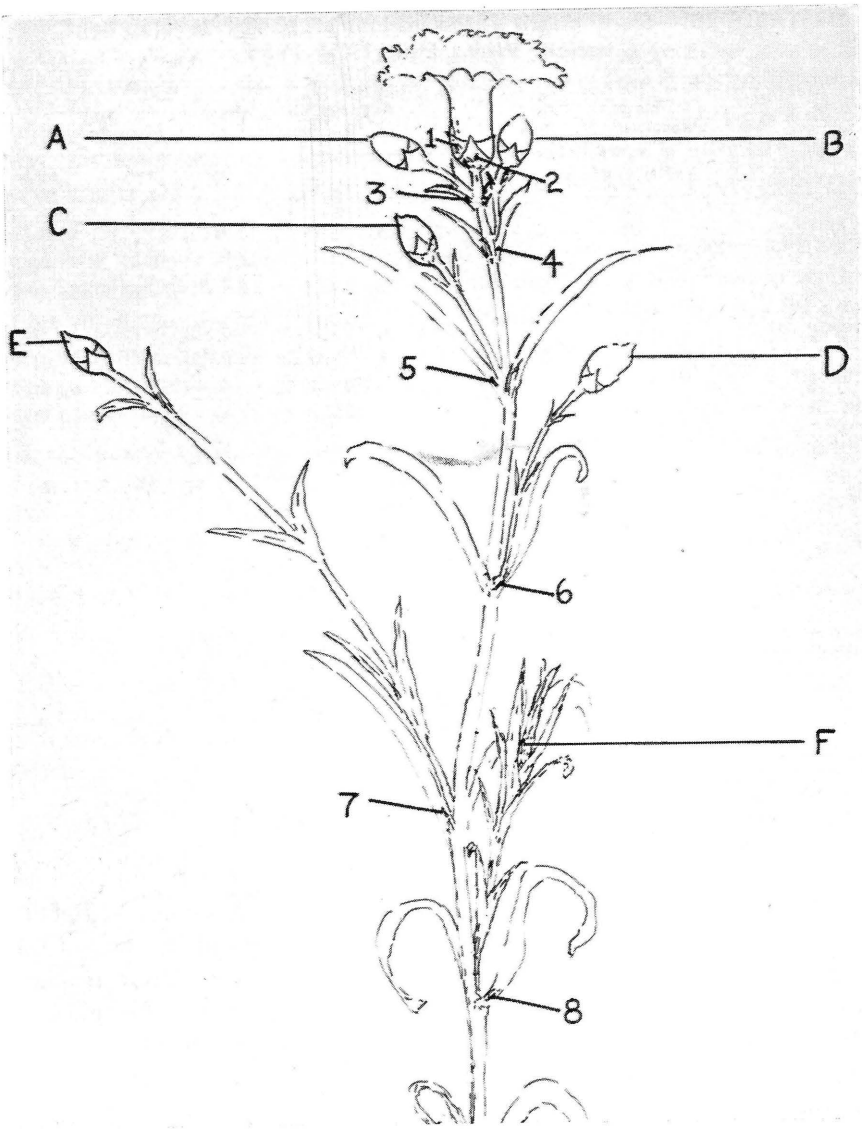

Fig. 8. Stem apex development in lateral shoots.

The lateral shoots are designated with letters A through F. The nodes are designated with numbers 1 through 8

TABLE 29.—Number of internodes and mean stem length of flowering stems, variety Sydney Littlefield, 1954-1955

Time of pinch		Date of observation							
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
July 17	No. observed	16	188	64	16	5	——	——	——
	Length in cm.	54.6	59.4	63.5	71.5	81.0	——	——	——
	No. of internodes	16.8	17.2	18.3	19.1	20.4	——	——	——
Aug. 20	No. observed	——	——	34	149	115	16	1	1
	Length in cm.	——	——	51.4	59.7	66.1	68.3	52.0	61.0
	No. of internodes	——	——	15.3	16.5	17.4	19.2	15.0	20.0
Sept. 16	No. observed	——	——	——	3	52	87	108	92
	Length in cm.	——	——	——	67.5	62.9	65.3	71.8	70.5
	No. of internodes	——	——	——	18.5	16.8	17.5	18.6	20.7
Basal shoots	No. observed	6	12	9	14	——	2	——	——
	Length in cm.	68.0	70.5	75.7	78.4	——	88.0	——	——
	No. of internodes	21.5	21.5	21.6	22.1	——	22.0	——	——

Floral Initiation and Development in Stored Cuttings

In a preliminary study of no pinch or single stem culture made in 1954, the plants which had been stored at 32° F. as rooted cuttings, flowered early on short stems. The plants that had received no storage or had been stored at 32° F. as unrooted cuttings flowered later on longer stems. All of the cuttings had been taken from stock plants when the shoots were about 6 inches long, so the stage of development at the time of removal from the stock plant was presumed to be the same.

TABLE 30.—Percentage distribution of extremes in number of internodes, variety Sydney Littlefield, 1954-1955

Terminal stems from July, August, and September pinches	
Total number	947
Percentage with 15 internodes or less	3.7 %
Percentage with 20 internodes or more	10.3 %
Basal stems	
Total number	43
Percentage with 15 internodes or less	0.0 %
Percentage with 20 internodes or more	100.0 %

TABLE 31.—Number of internodes and mean stem length of flowering stems, variety White Sim, 1954-1955

Time of pinch		Date of observation						
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
July 17	No. observed	134	137	32	12	——	——	——
	Length in cm.	78.4	83.8	90.7	103.3	——	——	——
	No. of internodes	17.3	17.9	19.0	20.8	——	——	——
Aug. 20	No. observed	8	59	173	124	59	——	——
	Length in cm.	62.3	62.7	70.1	82.2	86.0	——	——
	No. of internodes	14.3	14.4	15.5	17.5	18.1	——	——
Sept. 16	No. observed	——	——	1	22	59	72	94
	Length in cm.	——	——	64.0	77.4	80.9	94.3	96.0
	No. of internodes	——	——	15.0	16.8	17.4	19.7	21.3
Basal shoots	No. observed	27	6	5	——	——	——	——
	Length in cm.	90.7	105.8	98.7	——	——	——	——
	No. of internodes	21.5	21.9	23.6	——	——	——	——

Some commercial growers have reported that stored rooted cuttings produced more shoots after the first pinch, and that these shoots developed faster. To obtain further information on possible effects of refrigerated storage on rooted cuttings, a test was made in 1955. A total of 1000 rooted cuttings of the variety Gaiety were stored at 31° F. for 0, 1, 2, and 3 months. When received from the commercial propagator on April 3, all of the cuttings were placed in a steamed mixture of 3 parts soil and 1 part manure in 3-inch bands. At that time 24 samples were taken from cuttings in each storage group and the stem apex development was determined. The data in Table 35 show that the stored stems were further advanced in floral development than the ones that were not stored.

TABLE 32.—Percentage distribution of extremes in numbers of internodes, variety White Sim, 1954-1955

Terminal stems from July, August, and September pinches	
Total number	986
Percentage with 15 internodes or less	6.1%
Percentage with 20 internodes or more	18.1%
Basal stems	
Total number	38
Percentage with 15 internodes or less	0.0%
Percentage with 20 internodes or more	100.0%

TABLE 33.—Location of first vegetative lateral shoot (Stage I) at time of anthesis, varieties Sydney Littlefield and White Sim, 1954-1955

Position of node below terminal flower	Occurrence of first vegetative lateral shoot expressed as percentage of total of 75 stems
5	0
6	3
7	32
8	62
9	3
10	0

The period during which the first pinch was made began on April 30 and continued until May 18. The first pinch was made above the top lateral shoot when two or more lateral shoots were visible in the leaf axils. Each stem apex was examined at the time it was removed.

The stored cuttings developed faster and were ready for the first pinch before the cuttings that were not stored (Table 36). Those cuttings that had been stored for 1 or 2 months developed more rapidly than those stored for 3 months. The stem apex development was also more advanced in the stored plants (Table 37).

TABLE 34.—Number of internodes and stage of development of lateral shoots at the time of anthesis of terminal flowers, varieties Sydney Littlefield and White Sim, 1954-1955

Position of axillary or lateral shoot in relation to the terminal flower*	Number of internodes	Visible appearance of shoot	Stage of development of shoot†
1st Sub-terminal	3.0	Reproductive	IV b
2nd Sub-terminal	3.4	Reproductive	IV b
3rd Sub-terminal	4.0	Reproductive	IV b
4th Sub-terminal	4.3	Reproductive	IV b
5th Sub-terminal	6.0	Reproductive	IV b
6th Sub-terminal	9.0	Vegetative	I

*There are two nodes immediately below the terminal flower that do not produce lateral shoots. Thus the 6th sub-terminal lateral in this table is the same as the 8th node in Table 33.

†For description of stages see Figures 1 through 6.

TABLE 35.—Stem apex development at the end of the storage period, variety Gaiety, 1955

Number of months of storage	Number of stems examined	Percentage distribution by stage of development*				
		I	II	III	IV	IV b
0	24	95.8	0.0	4.2	0.0	0.0
1	24	70.8	25.0	4.2	0.0	0.0
2	24	58.3	37.5	4.2	0.0	0.0
3	24	79.2	20.8	0.0	0.0	0.0

*For description of stages see Figures 1 through 6.

TABLE 36.—The effect of length of storage on the time of the first pinch, variety Gaiety, 1955

Number of months of storage	Number pinched	Percentage of plants that received the first pinch on		
		April 30	May 11	May 18
0	249	47	38	15
1	241	74	22	4
2	243	80	15	5
3	257	50	41	9

TABLE 37.—The effect of the length of storage on the stem apex development at time of first pinch, variety Gaiety, 1955

Number of months of storage	Number examined	Percentage of stems in various stages of development*				
		I	II	III	IV	IV b
0	249	5	10	17	45	23
1	241	8	6	7	33	46
2	243	2	5	8	33	52
3	257	4	8	11	38	39

*For description of stages see Figures 1 through 6.

TABLE 38.—Number of shoots developed after the first pinch, variety Gaiety, 1955

Number of months of storage	Number of shoots	Percentage distribution by number of shoots						
		2	3	4	5	6	7	8
0	275	2	15	34	33	13	3	0
1	239	0	13	34	42	10	1	0
2	262	1	8	32	34	19	6	0
3	252	3	7	24	42	19	5	0

The plants were benched 8 × 8 inches in late May, and in June the lateral shoots that had developed following the first pinch were counted. The plants that had been stored had the greater number of shoots (Table 38). A total of 49 percent of the plants that had received no storage had five shoots or more. Of those plants that had been stored for 1 month, 53 percent had five shoots or more; and of these that had 2 months' storage, 59 percent had five shoots or more; and of those that had been stored for 3 months, 66 percent had five or more shoots. That made a difference of 17 percent between those stored for 3 months and those that were not stored.

DISCUSSION

Variation in Time Between Pinching and Crop Peak

The curve in Figure 9 was constructed from data in Tables 11, 15, and 16. It illustrates the elapse of time from the date the stems were pinched to the start of flower production, the period of peak production, and the end of production. Shoots developing from stems pinched in the spring flowered most rapidly, where shoots developing from stems pinched in the fall were the slowest in flower development.

The time relationship found here is in agreement to some extent with work reported from Colorado (1, 9, 10) as indicated below:

Time stems were pinched or cut	Number of months between pinching and the crop peak	
	Ohio	Colorado
July 1	4	4
July 15	4½	4½
August 1	5½	6
August 15	6½	6
October 15	7½	6 (1) 5 (9)

It appears that the primary difference occurred in the fall and winter period. Apparently the carnation flowers develop more rapidly during the winter under Colorado conditions than they do in Ohio, probably as a result of higher light intensities.

The stems pinched in April and May produced flowers in 3 months which was the shortest period of time, and the stems pinched in September produced shoots that were in peak flower production in 8 months (Figure 9).

Time of Flower Production from July, August, and September Pinches

The tabulation of the data from Figure 9 are shown below:

Time of Pinch	Time of Peak Production
January	June
February	June
March	July
April	July
May	August
June	September
July	November
August	January
September	April
October	June
November	June
December	June

This tabulation illustrates that the November through May production originated from shoots that were pinched in July, August, and September.

It should be noted that the stems pinched in July gave peak production of flowers in November. The stems pinched in September could also be expected to give peak production of flowers in a 2-month period of April and May; but stems pinched in August would provide for peak production over the 3-month period of January, February, and March. It could be expected, therefore, that the slight variation in the time of pinch, particularly in the month of August, could result in great differences in time of production in the spring.

Stems that were pinched or cut in the 5-month period of October through February, produced shoots that were in peak production of flowers in the month of June.

Holley (6) expected uniformly high production, October through June, from plants given the first pinch July 2 and succeeding pinches in the 2-week period following August 8. From other data of his, it would appear that even higher production could be realized in that period by extending the period of pinching. On the basis of data reported earlier,

Holley (1) believed that 6 to 7 months would elapse between the first crop in the fall and the return crop in the spring. For stems cut on October 1, this would place the return to peak production about April 1 to May 1. Later, Holley and Caparas (9) reported a 5-month period between an October 1st crop and the return crop in the spring. In either instance, this is a faster return than could be expected in Ohio, and it would appear to indicate that spring production could be increased to a greater extent in Colorado by pinching in September and possibly early October than would be possible under conditions in Ohio.

Rate of Flower Production as Affected by Time and Method of Pinch

There was a positive correlation between season of the year and rate of flower production. When the shoot growth took place during the high light intensity period of the year, flower development was rapid. Conversely, during the low light intensity period, the flower development was slower.

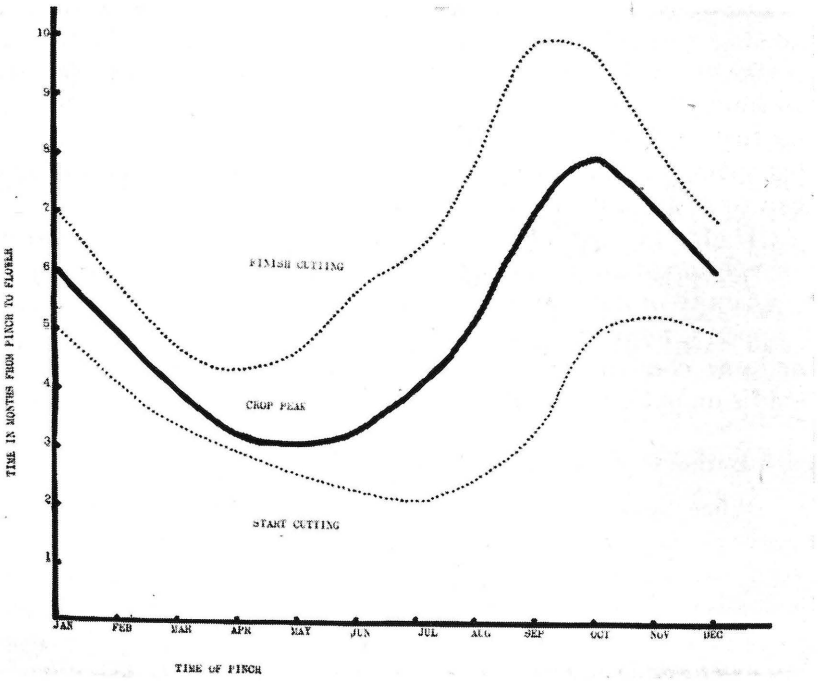

Fig. 9. Length of time from pinching to the start of production, peak production, and end of production.

This relationship between the rate of flower development and the light intensity is also illustrated by comparing the data from Colorado (1, 9, 11) with that from Ohio. The length of time from the date of pinching the stem to that of peak production was comparable during the summer and early fall, but the shoots developed more rapidly in Colorado during the winter. The light intensity in Colorado is considerably higher than in Ohio during the winter.

The stem apex development studies indicated that the rate of both floral initiation and development varied with the prevailing light conditions (Tables 17, 21, 22).

The time of the year when the stem is pinched would, therefore, determine the conditions under which the shoot will develop. If the stem is pinched before the high light intensity period of the year, the flower will develop rapidly.

It was also illustrated that the method of pinching determined the rate of flower production. When a high pinch was used, the rate of flower production was faster (Tables 6, 7, 8, and 9). This can be observed further by comparing the distribution of production in the last column of Table 1 with the first column in Table 10. In each instance the same variety was used, and the last date of pinching was the same; but the tests reported in Table 1 were conducted using older concepts of pinching. The stems were pinched lower in the earlier study than those reported in Table 10, and by comparing the two tables it can be seen that stems given the higher pinch (Table 10) produced an earlier crop than those given the lower or harder pinch (Table 1).

Holley (4) reported that the method of making the second pinch was not important in Colorado. He found that it did not affect quality or quantity of flowers, and their distribution was affected but slightly. It appears, however, in his work that the stems were pinched at about the same position but at various lengths of time after the first pinch. So it is quite likely that the two investigations cannot be compared.

Distribution of Flower Production as a Result of Pinching

When the shoots developed during the winter months, there was as long a period as 7 months between the time the first flower of a crop was produced until the last. The first flower from a stem pinched in September was produced in 3 months and the last flower was not produced until about 10 months after the date of pinching. The period of time over which a crop was produced was as short as 1½ months for the flowers from stems pinched in the spring. The summer crop peaked sharply and was cut in a short period of time, while the winter crop produced a flat peak and was cut over a long period of time.

This is believed to be related to the light conditions that are prevalent at the various seasons of the year. There was an inverse relationship between the length of time for production of a crop and the light intensity.

There was some hope when single pinch culture was first employed that the flower crops would be distributed over a shorter period of time than when multiple pinching was used. The data of Table 15 show that the flowers from stems given a single pinch were produced over a period as short as 2 months, or a period as long as 9 months. This compares favorably with the results obtained in multiple pinching, and indicates that plants pinched only once gave basically the same production curve as did multiple-pinched plants.

Limiting the number of stems on single-pinched plants (Table 16) did not cause the plants to flower in a short period of time. The flowers were produced over periods from 5 to 8 months whether the stems were pruned or not.

The terminal shoot usually flowers earliest, followed by the sub-terminal shoots. The data in Table 2 show that the sub-terminal shoots actually flowered several months after the terminal shoot. As noted earlier, the stems were pinched at a low level in this study. This may have caused a greater difference in time between flowering from terminal and sub-terminal shoots.

It was demonstrated in the work reported in Table 20 that the shoots had varying numbers of internodes at the time of flowering, and the shoots that arose from the base of the plant had seven more internodes than the shoots that originated toward the top of the plant. It was likely that the basal shoots developed over a longer period of time, and if both the top shoots and the basal shoots were pinched at the same time, there could be a time difference in flowering.

An inspection of the data presented in Tables 19, 23, and 25 reveals that the shoots which reached the floral initiation stage first had the fewest number of internodes, and those shoots that initiated flower buds later had a greater number of internodes. This was true whether the stems were pinched in February, April, July, or September. This relationship existed for both top and basal shoots. Since this occurred over a considerable period of the year, it is believed that there are causes of variability in rate of flower development in addition to temperature, light, and place of shoot origin. One possible cause could be the vigor of the shoot.

Development of the Stem Apex

In this work it appeared that differences in stem apex development among varieties was slight. Why basal shoots developed more slowly than top shoots was not determined. It could be associated with physical conditions such as shading from the upper portions of the plant or for various physiological conditions such as the supply of hormones or food.

The information on stem apex development of the sub-terminal shoots (Tables 33, 34, and Figure 8) shows that there was not a uniform progression of stem apex development from one sub-terminal shoot to the next, at least not for the first seven or eight nodes. The possibility could exist, however, that the shoots below the seventh or eighth nodes develop at different rates depending on their location. The earlier pinching trials (Tables 6, 7, 8, and 9) did establish that flower production was more rapid when the second pinch was made rather high on the plant but below the eighth node from the apex. However, no stem apex development observations or internodal counts were made at that time on the flowers that were produced.

Apparently, floral initiation was promoted in rooted cuttings that were stored at 31° F. (Tables 25 and 37). This could be another factor causing variability in time of flower production, but possibly it could also be used to promote earlier development and more lateral shoot growth (Tables 36 and 38).

Timing of Second Year Plants

Any of the pinching methods on plants carried for two seasons reduced the yearly flower production (Table 12) and thus were considered unsatisfactory. Flower production following pinching was much slower with 2-year old plants than in their first year (Table 13), and less than one flower was returned per pinched stem. The crowded conditions and the consequent shading of the stems was probably responsible for these differences from those of 1-year culture. There appeared to be no reliable method of pinching 2-year old plants to control the time of flower production.

After experimenting with several different methods of pruning, pinching, or thinning, Holley (3 and 7) concluded that the stems should be cut low in the spring, followed with a general cut-back in May. Later he recommended gradual pruning by cutting the stems back to within 3 inches of the dead foliage. He advocated pruning in four steps at 2-week intervals, or in three steps at 3-week intervals. For Colorado conditions, plants pruned in this manner in May returned to production in December.

RECOMMENDATIONS FOR CARNATION CROP CONTROL IN OHIO

Control of carnation cropping can be realized by adjusting the time of pinching for anticipated weather conditions and by regulating the height of the pinch on the stem.

For Ohio, if continuously heavy cropping is desired during the period from November through May, stems must be pinched in the period from late June through September. In order to have stems at the right stage for pinching during that 3-month period, propagation should be scheduled for February 15 to March 15. First pinching can usually commence from 5 to 6 weeks after the plants are removed from the propagation bench, and pinching of the shoots that develop from the first pinch can then start in June.

A high pinch should be used, and whenever possible, it should be made above two or more lateral shoots on the stem.

After the middle of July the pinching should be confined to the shoots that have visible flower buds. In this way the shoots that would flower in late summer or early fall are removed, and the return production from the pinched stems will come in late winter and early spring.

Shoots that arise from the middle to basal part of the plant take longer to produce flowers; however, if a high pinch is used, the shoots developing from these stems will flower more quickly.

Figure 10 and Tables 33 and 34 illustrate the importance of selecting proper stems for propagation. If tips from long stems that have grown for some time are used, the terminal and some of the lateral flower buds may already be initiated although not visible. This produces a young plant that exhibits a flower bud soon after planting, and the sub-terminal six or seven shoots may have flower buds on thin and short stems. Such plants must be pinched low in order to get strong vegetative shoots; usually, fewer axillary shoots will grow and a longer time is needed for them to develop. It will vary somewhat, but tip cuttings from shoots that are 8 inches or less in length will usually be vegetative.

If continuous production from single pinch culture is desired in the period from November through May, a schedule should be made so that various groups of cuttings can be pinched in July, August, and September. For continuous heavy production in January through March, several lots of plants would be needed for pinching a few days apart in August.

It may be advtantageous commercially to use stored rooted cuttings for planting since those stored longest showed the greatest percentage of plants producing five or more shoots after pinching. If this will produce more lateral shoots at an earlier time, it would be useful particularly when operating on a short time schedule in late spring.

SUMMARY AND CONCLUSIONS

1. Several phases of carnation crop control work from 1948 to 1955 are described, and the results and their application to commercial carnation forcing in Ohio are discussed.

2. The interval between pinching at various times of the year and the peak of crop production varied from 3 to 8 months.

3. November-through-May flower production resulted primarily from shoots developing from stems pinched in July, August, and September.

4. At the time of floral initiation the number of internodes on the majority of the stems originating from the upper portion of the plant varied from 16 to 19. Stems originating from the basal portion of the plant had a greater number of internodes and developed more slowly.

Fig. 10. Variations in the stage of development of young carnation plants propagated the same date.

5. Regardless of the time of pinching, those shoots that initiated flower buds early had fewer internodes than the shoots from a similar pinch that initiated flower buds later.

6. Floral initiation will occur in rooted cuttings stored at 31° F.

7. The time relationships for crop production were found to be the same for either single- or multiple-pinch culture.

8. At anthesis of the terminal flower, the sub-lateral shoots at the first seven or eight nodes had well-developed flower buds on short, thin stems. At the next lower node the lateral shoot was vegetative and at a later date produced a flower on a stem of 17 internodes.

9. The rate of flower production is believed to be affected by light intensity and temperature, method of pinching, and other factors not as yet determined.

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